IMPROVING QUALITY AND EFFICIENCY IN DIE CASTING OF COMPLEX HOUSINGS

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Abstract

In order to provide ecological balance, new technologies are being developed to reduce fuel consumption. Within these new technologies, usage of light alloys such as aluminum and magnesium has gained great importance in the automotive applications. The advantages of aluminum alloys in terms of light weight, recycling, machinability and corrosion resistance led to increase application area of these alloys. Due to these characteristics of aluminum alloys, fuel-saving light-weight material selection plays an important role for automotive parts. Aluminum applications increase not only in automotive, but also in aerospace, space shuttle, marine, and defense applications. According to the production methods, aluminum alloys are generally classified as casting, sheet, forging and extrusion. Aluminum die casting alloys are generally used the production of suspension systems, engines and gears parts. However, with the developing aluminum casting technologies, the aluminum die casting method makes it possible to manufacture multiple body parts in one piece. It is predicted that number of aluminum die casting parts will increase, especially in electric vehicles. In this study, the importance of the use of aluminum die casting alloys in the automotive industry is emphasized. Research and trends so far of the development of aluminum die casting alloys are also summarized.

Keywords: Light weighting, Aluminum casting alloys, Fuel consumption.

Introduction

Recently, weight reduction through the use of light-weight materials plays an important role in improving fuel economy and reducing harmful emissions. The importance for reducing CO2 emissions by lightweight structure design for automotive applications, lead to increase the usage of medium strength aluminum alloys. Replacing steel components with high strength aluminum alloys became a spot light in automotive industry for light-weighting. Aluminum can be assumed that the 2nd metal element which can be provided on earth. It is the most used material in today's industry after steel. Aluminum alloys are widely preferred due to their light-weight, low density, good formability and high corrosion resistance characteristics. In last decade studies on energy saving reveals that production of light and economical vehicles plays an important role for less fuel consumption. Aluminum alloys are widely preferred in passenger cars, buses, primarily in trains as well as the construction of marine applications. In fact, aluminum alloys have been used in the aviation and defense industry for a long time. The adaptation of aluminum to the automotive industry has started due to the advantages seen in aviation and defense applications. Casting aluminum alloys are widely used in automotive industry. Aluminum casting is a variation of this that uses only aluminum and aluminum alloys as the liquid metal that is poured into the mold. Aluminum castings are used to make complex and detailed parts very efficiently. Casting aluminum alloys are quite widespread and find more and more applications in modern industry. According to different estimates, up to 20–30% of all aluminum products manufactured worldwide are used for aluminum die castings. Due to considerable improvements in casting technologies, now it is possible to produce high-quality aluminum die casting components with properties that are comparable to those of similar wrought products.

Mold Making

The first phase in the sand casting method is production of the casting mould. This move should be performed in expendable mould process for each casting. The sand is packaged with half of the mould. A replica external cast shape is packed in sand. When the design is withdrawn, the cavity that forms cast rests any internal casting characteristics not generated by pattern consists of separate sand centres before mould formation. More detail on mould making is described in following part. The period required to mould includes design, packaging and removal of the pattern. The construction time for mould depends on the component size, the number of cores sand mould shape. The moulding time is greatly increased when heating or baking time is needed. In order to facilitate casting removal, lubrications are also applied to surfaces of the cavity.

The usage lubricant increases the flow and finish metal. The lubricant used is dependent on the sand and hardened metal temperature.

Melting & Pouring

Melting is the preparation and transformation of the molten metal from a solid to a liquid state in a furnace according to the chemical composition for casting. At a fixed temperature, the moulded metal is maintained in a stove, Once the mould has been tightened, the mould is moved into the foundry's moulding area by a ladle. The dumping may manually or automatically, be finished. Enough molten metal must be poured to fill the whole cavity and all the channels in the mould. The filling time is rather short to prevent early solidification any part alloy.

Cooling

The molten metal injected into mould starts cooling and consolidating in the cavity. The final mould is formed before the whole void Filled and solidified with molten metal. Until the cooling period is done, mould cannot be opened. The optimum cooling time can be calculated on basis of grid thickness and metal temperature. The solidification process leads to many possible defects. Because any molten metal falls so quickly, it may shrink, divide incomplete. Preventive measures should be taken for design of the portion and the mould and addressed later.

Literature Review

Drezet, JM, Rappaz et al (2000) Casting is one of humanity's oldest production methods. The method of casting has subsequently advanced rapidly and is now being used for casting complex moulded components in both metal and non-metal industries. In certain situations it provides the only way to manufacture crucial components such as blades used in a gas turbine's high-temperature level. The research confirms the impact on mechanical properties of casting defects o1, especially in aluminium foundries. Casting defects, such as an oxide movie, behave as cracks and reduce tension specimens' resilience. Aluminum alloy castings arc significantly weakened by the addition of the Casting aluminium oxide. If the alloy is poured into the mould or dies, the ox idea produced on the surface of the fluid alloy is inserted into the casting. The variations in character between the strengthened and unreinforced sections of the casting allow the casting to crash around these faults. These oxide defects across the reinforced zone of the casting create a challenge.

H. Mayer, (2003), investigated the effects of alloy composition on porosity the fatigue limit. The experiments were carried out on different types of alloys of aluminium to know its strength and failure in maximum the fatigue crack. It was observed that the porosity was the major causes for crack formation. The crack was initiated even for small porosity; the crack starts the fatigue in all the alloys up to certain limit but studied the casting defects in Mg-Zn Al- alloys with different combinations of Al and Zn. It was noticed that the defects vary as combination changes and the hot tearing susceptibility changes as Zn increases up-to sometime and then decreases. The yield strength was increased due presence of Al and Zn. The tensile strength and ductility depend on casting defect. It was concluded that the mechanical properties were increased by adding Al and Zn.

Kumar Sudhir et al. (2006) That was mentioned Taguchi was employed to test process parameters such as the grain fineness quantity, vibration period and vacuum level and the flow temperature in research into EPC. The architecture of Taguchi was used for this purpose. The remaining parameters were important in determining the surface roughness of the casting with the exception of pouring temperature. In another study, Sun notes that the Taguchi approach was used for cylindrical magnesium casting process optimisation and concluded that parameters of the gating mechanism, including the gate height, distance, runner height and width, affect process parameters.

Dobrzanski et al. (2007) The technique for automated monitoring of the technical phase of manufacture of elements from aluminium alloys has been used by. The automated quality evaluation technique of these components, based on image recognition, by using the artificial 75 intelligence platform, obtained with x-ray defect detection. This method is to allow the types and classes of defects developed during casting of aluminium alloy elements to be determined, the photographs acquired using the X-ray method of error detection can be made use of and the neural network data to be prepared, including standardisation, the correct image analysis and selection and calculation. The correctly defined amount of items makes it possible for this technical process management to minimise the number of coating defects by correctly correcting the process. Controlling the technical method using computer-generated product quality knowledge will allow this process to be optimised and thus reduce faulty casts and thus reduce expenditure and environmental emissions.

Madan et al. (2009) To decide the separating path for die-cast parts from available alternatives. They have established a selection criterion using eleven influencing factors in the selection of partition path related to part-geometry and die-casting. Using tessellated component model to find reasonable moulding instructions. Its triangular facets decide the tessellated component model. The facets are divided into ups and downs. The machine detects the undercut features in a given direction by looking for partially or completely invisible up-facets. Following that, the undercut-free directions are determined. The algorithm performs a draught study, applying the requisite draught to the vertical faces of the component to facilitate removal from the mould. The algorithm cannot be used on units that need a side centre or a multi-part mould.

Methodology

The sample comprised of 200 tonnes of HPDC-molded AZ91D alloys. Table 3 shows the configuration for AZ91D. The temperatures were at 578 and 430 degrees Celsius, respectively, for molten fluid and solid magnesium. A vacuum pump, vacuum tank vapour were included in study. The original technique of casting was to transfer molten fluid to injection chamber. Secondly, plunger filled the cavity and passed through sprinkler gap. There was activation vacuum mechanism pressure in the die cavity was less than in surrounding atmosphere. From the beginning filling procedure until end cavity was constantly emptied. The dietary temperature was kept at 200 C for both the HPDC and vacuum technology. At 630 C was maintained pouring temperature. During casting a number of plunger speeds were employed between 0,14 and 0,83 m/s. Research on tensile was conducted utilising Universal Electromechanical Instron 5569 in KS B0801 subsize. Without heat treatment, traction samples were evaluated. A double phase microstructure was detected with +b in pressure applied to the dieting sample AZ91D and the two microstructuring tests were done at ambient temperature (25 C). SEM SEM Examples for microstructural examination from casting samples have been eliminated. An optical microscope (OM), along with quantitative metallography, has been used to study the microstructure HPDC and vacuum. OM specimens were developed using usual Sic paper and polishing procedure, followed by 60% ethylene glycol solution, 20% acetic acid and 1% HNO3 concentrated in water.

Result

To analyse the findings and suit suitable model for the experiments, Quik Cast programme was used. Different method parameters have been analysed in order to clarify impact on final outcome of each. The criteria for numerical simulations have already been indicated (Numerical simulation). The results examined by the programme were fill period and overall shrinkage porosity.

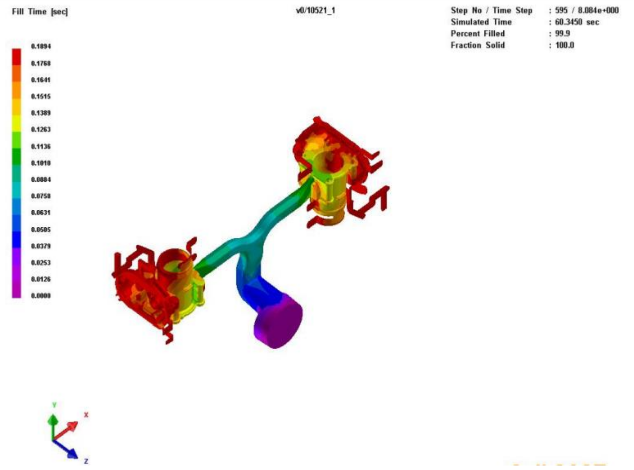


Figure: 6.4 Fill time for the 1st experiment

Displays the part's filling time features. The cavity of 0.1500 seconds is packed with molten metal. The filling period is the length until the molten metal fills the space. The red-colored areas shown at the end of the part are sensitive areas with an average filling period of 0.1894 seconds, which means that the bottomlessness is incomplete. The green coloured area represents the optimal degree of solidification of molten metal. Blue and purple regions mean faster molten metal filling. But, as it happens in the runner area, this simulation is not essential.

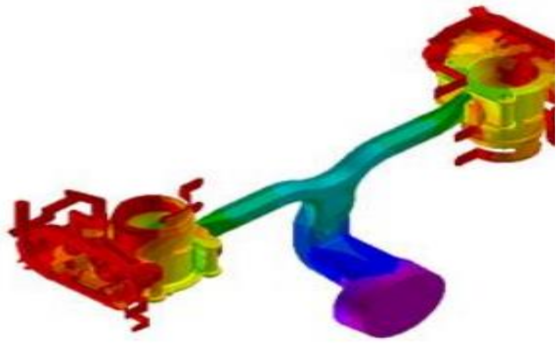
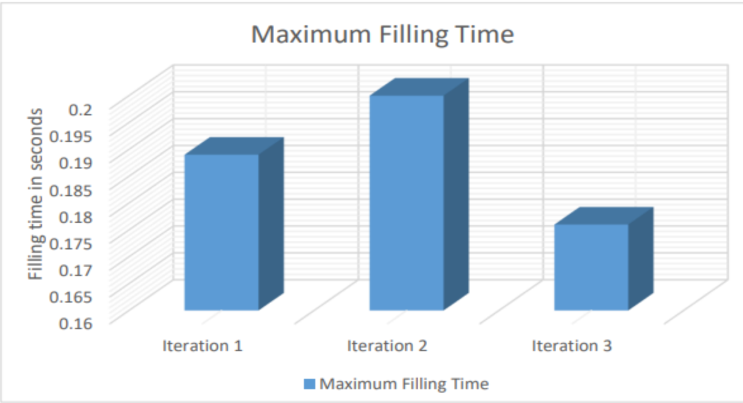


Figure: 6.5 Analysis image of the 1st experiment

The figure displays an enlarged picture of the 1st experiment simulation result. Red-colored regions signify the sensitive spots. These areas show that the molten metal in these regions has been partly filled. This suggests even despite injection, It didn't solidify molten metal. The filling time is influenced by the injecting speed die-temperature molten metal. Temperature die is significant parameter, as described in literature reviews. The molten metal overfills cavity that makes thermal bubbles more likely when dying is too hot. However, in this simulation, molten metal does not contact corners component where it is clear that whole time is 0.1890 seconds.

The third filling session of the experiment. In this experiment, die-temperature and speed were raised further to 205°C and 0.065 m/s respectively. Here we may see sensitive red-colored areas are not present. Rather, field coloured mostly blue and violet. Given the high speed and die temperature, in most important areas the molten metal was not able to complete cavity. This is another case where the defect identified as malfilling takes place.



Graph: 6.1 representation of maximum filling time for each simulation

A 3D clustered column graph was created determine optimal filling period for a simulation. Iteration is the simulation, whereas blocks are the time of filling. It is clear that iteration 2, preceded by iteration 1, and then iteration 2, has maximum filling time. While the second simulation has highest recharge period, in crucial area it became clear that component did not have hot spots, rendering it nearly perfect part of high quality. The second maximum filling period is given by iteration 1. This simulation filled the cavity for a longer time such that hot spots were placed at the corner of the piece. The speed was too poor to be perfectly solidified. The iteration 3 is filled in the lowest maximum period. The cavity was filled in this case in a brief period of time. The first stage speed was 0.065 m/s, which is 0.05 m/s better than the iteration 2 in this case. The poor filling fault in certain parts was affected by this trait and ultimately resulted in rejection. And the best 1st stage and 2nd stage of plunger velocities is determined. Further calculations with varying plunger speed and die-temperature thresholds were conducted to consider the characteristic of fill time. Though simulations were carried out at the various parameter levels, the outcome was nearly the same. for residual simulation effects.

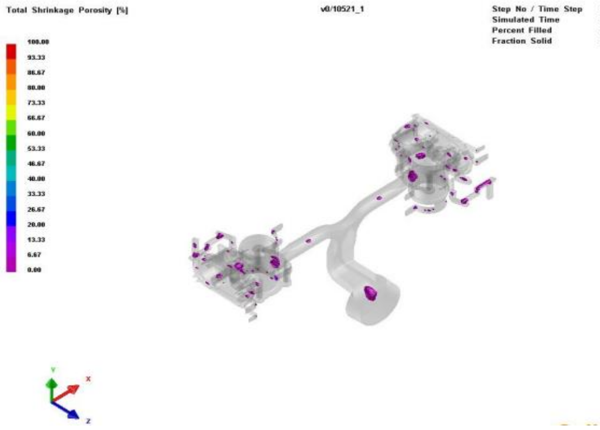


Figure: 6.8 Total shrinkage porosity for the 1st experiment

The first porosity distribution observation. Porousness induced by various factors like tumbling speed and stirring is fault. No hot spots have been detected in sensitive areas or areas, indicating there is no 100% porosity zones. The image reveals porosity concentration around 20 to 30%, therefore porosity exists, but not in a higher porosity or cluster.

The magnesium HPDC tensile properties depend, as discussed above, on the size of the grain. Therefore, cooling curves obtained from casting simulation tools are first contrasted in this portion, findings of tensile testing are then investigated according to the fact that dependency indicated above tensile properties of casting part 1 depends primarily on amount of porosity due to incorrect drift filling. The porosity effect is more important than the kernel size effect. Therefore, no research of cooling curve and grain size for this cast element was performed.

Table: 6.11 Mechanical properties of cast part

Sample	T_m (^{0}c)	Thickness(mm)	$\sigma_{0.2}$ (MPa)	UTS (MPa)	Elongation (%)
1a	650	5	82.24	91.14	5.59
1b	650	5	63.55	69.97	2.21
average	650	5	72.9	80.56	3.9
2a	670	5	110.5	147.6	6.98
2b	670	5	85.48	107.48	3.42
average	670	5	97.99	127.54	5.2

Conclusion

Thermographic analysis to consider the die action following each shot. Die is a significant variant of the die-casting method with heavy strain. Thermographic photographs can then be obtained and used to investigate the temperature distribution on a die after each fired, and the lubrication and cooling mechanism for the die may be analysed.

The continuous casting method for the desired use is granted by a complex CFD analysis. For CFD research, a standard turbulent k- model is used. This simulation is carried out using a tundish with and without the rectangular and a curved dam and weir and on the basis of measured period of residency from the DPM model, it was found that the rectangular dam and weir is the best way to reduce turbulence on the SEN-side by inserting a massless particle. The results and the discussion showing the usage of casting powder in the mould would also display a two phase model, and A slag profile is shown. Based on the results, the thickness of the belt is changed and the crack reduced by 25 percent. This means that it is possible to say that the mathematical modell is very useful in predicting the flux behaviour and temperature profiles and the temperature profile is very high in the case of the mathematical model.

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